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1. Your reference	PDC/N15408GB	
2. Patent application number *(The Patent Office will fill in this part)*	0402687.8	- 6 FEB 2004
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Patterning Technologies Limited Fujifilm House Boundary Way Hemel Hempstead Hertfordshire HP2 7RH	
Patents ADP number *(if you know it)*	8307944002	
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom	
4. Title of the invention	Electronic device and method of manufacture thereof	
5. Name of your agent *(if you have one)*		
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	MATHYS & SQUIRE 100 Gray's Inn Road London WC1X 8AL United Kingdom	
Patents ADP number *(if you know it)*	1081001	

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
	GB	0313617.3	12 June 2003

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
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b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
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Description	28
Claim(s)	11
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Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	UNITED KINGDOM PATENT APPLICATION NO. 0313617.3 (AGENT'S REF. 25456)

11. I/We request the grant of a patent on the basis of this application.

Signature Mathys & Squire Date

MATHYS & SQUIRE 6 February 2004

12. Name and daytime telephone number of person to contact in the United Kingdom — DR PAUL COZENS - 020 7830 0000

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ELECTRONIC DEVICE AND METHOD OF MANUFACTURE THEREOF

The invention relates to a device, particularly an electronic device such as a microelectronic device, and to a method of manufacture thereof, and in particular to the design of an inorganic, polymeric or organic microelectronic device.

Of particular interest is the device design and/or the method of manufacture applied to a thin film organic field-effect transistor (O-FET) as used in polymer electronic (Polytronics) and plastic electronics (Plastronic) applications, or to inorganic and hybrid organic-inorganic structures, and in particular to opto-electronic devices, such as photovoltaic cells and photodiodes, and quantum wire devices and interconnections.

The device design and/or method of manufacture have particular application to medical and bioelectronic sensors, particularly active sensors, and actuators, and to point of care disposable electronic analysing systems.

The invention relates in particular to the manufacture of an electronic device using printing technology, particularly inkjet printing technology as described for instance in International (PCT) Patent Publication No. WO 97/48557, in particular and without limitation at pages 7 to 18, International (PCT) Patent Publication No. WO 99/19900, in particular and without limitation at pages 65 to 68, and United Kingdom Patent Application No. 0313617.3 (agent's reference 25456), in particular and without limitation at pages 20 to 48, each in the name of Patterning Technologies Limited, each of which is hereby incorporated by reference.

In light of the placement accuracy limitations associated with current Original Equipment Manufacturer (OEM) printhead technology the present invention provides, in one aspect, alternate device designs that overcome, at least to some degree, the limitations observed.

The need to use containment wells or trenches limits the ability to construct novel device designs as well as the use of alternate materials other than polyimide. In-line drop placement may be used to fill a containing trench.

Use may be made of a hydrophobic-hydrophilic surface feature, based for instance on polyimide, to form a device, such as an organic field-effect transistor in one example, where the contacts, for instance metal polymer contacts, are deposited using ink jet printing.

In one aspect of the invention there is provided a method of forming an electronic device comprising arranging a surface such that deposition material deposited on a receiving portion of the surface will flow to a desired portion of the surface.

Thus improved control over the distribution of the deposition material is provided.

Preferably, the method comprises using the technique of drop on demand printing to deposit at least one droplet of deposition material.

The deposition material may be deposited on the receiving portion in such a way that a pre-determined coverage of the desired portion by the deposition material is obtained.

Preferably, the step of arranging the surface comprises forming a surface pattern.

Preferably, the receiving portion comprises a reservoir for the deposition material, and preferably the reservoir comprises a portion of the surface having a desired wetting property arranged so as to control flow of deposition material from the reservoir.

The receiving portion may be separate from the desired portion, and preferably is remote from the desired portion. By making the receiving portion remote from the desired portion, the coverage of the desired portion by deposition material may be

independent of any deleterious effects due to impact of the deposition material on the receiving portion. In particular, the coverage of the desired portion may be unaffected by any splatter of deposition material following impact of the deposition material on the receiving portion, or from washover of impact waves. Thus the coverage of the desired portion with deposition material may be more reliably controlled and may be more uniform than otherwise.

The desired portion may comprise an active region of the electronic device to be formed, and such active region may be a region where current flows and/or where voltage is applied when the device is in use.

The method may further comprise arranging the surface so that deposition material deposited on one or each of a plurality of receiving portions of the surface will flow to a desired portion of the surface, and preferably will flow to a plurality of desired portions of the surface.

The method may also comprise arranging the surface so that the receiving portion is at least as large as the resolution with which the deposition material can be deposited on the surface by apparatus used to put the method into effect.

Preferably the step of arranging the surface comprises arranging the surface so that the deposition material deposited on the surface will flow by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect.

Preferably deposition material deposited on the surface will flow by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect.

In a further aspect, there is provided a method of forming an electronic device, comprising arranging a surface and/or selecting deposition material such that the deposition material when deposited on the surface will flow to a desired portion of

the surface by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect.

Preferably the method further comprises using the technique of drop on demand printing to deposit at least one droplet of deposition material.

Preferably the step of arranging the surface comprises providing a selected portion of the surface with a desired wetting property, preferably by changing the wetting property of the selected portion of the surface.

This feature is particularly important and so in a further aspect there is provided a method of forming an electronic device, comprising providing a selected portion of a surface with a desired wetting property and depositing deposition material on the surface, so that the distribution of the deposition material on the surface is dependent upon the wetting property of the selected portion.

Preferably the deposition material is deposited using the technique of drop on demand printing.

Variation of the wetting property over at least part of the selected portion may be provided and preferably such variation is a continuous variation.

There may also be provided a discontinuous variation of the wetting property between at least part of the selected portion and at least one adjacent portion of the surface.

Preferably a difference in the or a wetting property between the selected portion of the surface and a further portion of the surface causes containment of the deposition material, and preferably causes containment of the deposition material within at least part of the selected portion or within at least part of the further portion.

The method may further comprise coating the surface.

Preferably the step of coating the surface comprises coating the surface with a layer having a different wetting property from the surface, and preferably the layer comprises a non-wetting layer and/or comprises a monolayer and/or comprises a self-assembled layer.

The method may also comprise applying radiation to the surface and/or to the or a layer on the surface, preferably so as to change the or a wetting property.

The radiation may comprise electromagnetic radiation, preferably ultraviolet radiation. In particular, the radiation may comprise laser radiation.

The laser radiation may be applied using an excimer laser.

The surface and/or the or a layer on the surface may be treated by laser ablation and/or by corona discharge, preferably so as to change the or a wetting property.

Preferably, the step of arranging the surface comprises providing a temperature variation across at least part of the surface, and preferably that temperature variation causes flow of the deposition material across at least part of the surface.

Preferably, the method further comprises heating or cooling the deposition material and/or at least part of the device, preferably so as to control flow of the deposition material.

At least one dimension of the desired portion and/or the surface pattern and/or the selected portion may be less than one micron and/or may be of the order of the wavelength of ultra-violet light.

Flowing fluid may be applied to the deposition material to assist the flow of the deposition material over the surface, and preferably the flowing fluid comprises a gas jet shower.

Thus flow of the deposition material into a region of the surface which would otherwise be restricted by geometrical effects and/or surface tension effects may be obtained.

The flowing fluid may be heated, and may in particular be selectively heated, for instance in order to influence the rheology of the deposition material and/or the flowing fluid, in particular during the flow process of the deposition material over the surface. In the case of a gas jet shower, the gas may be selectively heated.

The deposition material may be deposited on the receiving portion using at least one of ink jet printing, an OEM printhead, high resolution spraying, and liquid continuous jet streaming, preferably liquid continuous jet streaming defined by a fixed duration actuating pulse.

The electronic device may comprise at least one of a transistor, a resistor, a conductor, a diode, a capacitor, an inductor, a surface coil, a josephson junction, an organic, inorganic or hybrid organic-inorganic structure, an opto-electronic device such as a photovoltaic cell or photodiode, a quantum wire device and/or interconnection, or a composite device made from a plurality of such devices, and may comprise in particular a butterfly transistor.

The electronic device may comprise, or be included in, a medical or bioelectronic sensor, particularly an active sensor, an actuator, or a point of care disposable electronic analysing system.

Preferably deposition material is deposited repeatedly and/or further deposition material is deposited, in order to form a layered device.

In a further aspect, there is provided apparatus for forming an electronic device comprising means for arranging a surface such that deposition material deposited on

a receiving portion of the surface will flow to a desired portion of the surface, and means for depositing deposition material on a receiving portion of a surface.

The depositing means may be adapted to use the technique of drop on demand printing to deposit at least one droplet of deposition material.

Preferably the arranging means is adapted to select and/or to change a property of the receiving portion.

The depositing means may be adapted to deposit the deposition material on the receiving portion in such a way that a pre-determined coverage of the desired portion by the deposition material is obtained.

The arranging means may be adapted to form a surface pattern on the surface.

Preferably, the receiving portion comprises a reservoir for the deposition material, and preferably the reservoir comprises a portion of the surface having a desired wetting property arranged so as to control flow of deposition material from the reservoir.

The receiving portion may be separate from the desired portion, and may be remote from the desired portion.

Preferably, the desired portion comprises an active region of the electronic device to be formed, and preferably the active region is a region where current flows and/or where voltage is applied when the device is in use.

The arranging means may be adapted to arrange the surface so that deposition material deposited on one or each of a plurality of receiving portions of the surface will flow to a desired portion of the surface, and preferably will flow to a plurality of desired portions of the surface.

The arranging means may also be adapted to arrange the surface so that the receiving portion is at least as large as the resolution with which the deposition material can be deposited on the surface by apparatus used to put the method into effect.

The arranging means is preferably adapted to arrange the surface so that the deposition material deposited on the surface will flow by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow.

In a further aspect of the invention there is provided apparatus for forming an electronic device, comprising means for arranging a surface such that deposition material deposited on the surface will flow to a desired portion of the surface by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow, and means for depositing the deposition material on the surface.

Preferably the depositing means is adapted to deposit at least one droplet of deposition material using the technique of drop on demand printing.

The arranging means may be adapted to change a wetting property of a selected portion of the surface.

In another aspect of the invention, there is provided apparatus for forming an electronic device, comprising arranging means adapted to change a wetting property of a selected portion of the surface so that the distribution of deposition material deposited on the surface is dependent upon the wetting property of the selected portion, and means for depositing deposition material on the surface.

The depositing means may be adapted to deposit at least one droplet of deposition material using the technique of drop on demand printing.

The arranging means may be adapted to provide variation of the wetting property over at least part of the selected portion, and preferably the variation is a continuous variation.

The arranging means may also be adapted to provide discontinuous variation of the wetting property between at least part of the selected portion and at least one adjacent portion of the surface.

Preferably the arranging means is adapted to provide a difference in the or a wetting property between the selected portion of the surface and a further portion of the surface so as to cause containment of the deposition material, and preferably so as to cause containment of the deposition material within at least part of the selected portion or within at least part of the further portion.

The apparatus may also comprise means for coating the surface.

Preferably the coating means is adapted to coat the surface with a layer having a different wetting property from the surface, and preferably is adapted to coat the surface with a non-wetting layer and/or a monolayer and/or a self-assembled layer.

The apparatus may also comprise means for applying radiation to the surface and/or to the or a layer on the surface, preferably so as to change the or a wetting property. The radiation may comprise electromagnetic radiation, preferably ultraviolet radiation, and in particular the radiation may comprise laser radiation. The apparatus may further comprise an excimer laser.

Preferably the apparatus further comprises means for treating the surface and/or the or a layer on the surface by laser ablation and/or by corona discharge, preferably so as to change the or a wetting property.

Preferably, the apparatus further comprises means for providing a temperature variation across at least part of the surface, and preferably that temperature variation is such as to cause flow of the deposition material across at least part of the surface.

Preferably, the apparatus further comprises means for heating the deposition material and/or at least part of the device, preferably so as to control flow of the deposition material and/or so as to melt the deposition material.

Preferably, the apparatus further comprises means for cooling the deposition material and/or at least part of the device, preferably so as to control flow of the deposition material and/or so as to solidify the deposition material.

Preferably at least one dimension of the desired portion and/or the surface pattern and/or the selected portion is less than one micron and/or is of the order of the wavelength of ultra-violet light.

The apparatus may further comprise means for applying flowing fluid to the deposition material to assist the flow of the deposition material over the surface, and preferably the flowing fluid comprises a gas jet shower.

The application means may be arranged so as to obtain flow of the deposition material into a region of the surface which would otherwise be restricted by geometrical effects and/or surface tension effects.

The apparatus may further comprise means for heating the flowing fluid, preferably for selectively heating the flowing fluid. Such means may be suitable for selectively heating gas in the gas jet shower.

Preferably the deposition means is adapted to deposit deposition material on the receiving portion using at least one of ink jet printing, an OEM printhead, high resolution spraying, and liquid continuous jet streaming, preferably liquid continuous jet streaming defined by a fixed duration actuating pulse.

The electronic device may comprise at least one of a transistor, a resistor, a conductor, a diode, a capacitor, an inductor, a surface coil, a josephson junction, an organic, inorganic or hybrid organic-inorganic structure, an opto-electronic device

such as a photovoltaic cell or photodiode, a quantum wire device and/or interconnection, or a composite device made from a plurality of such devices, and may comprise in particular a butterfly transistor.

The electronic device may comprise, or be included in, a medical or bioelectronic sensor, particularly an active sensor, an actuator, or a point of care disposable electronic analysing system.

The deposition means may be adapted to repeatedly deposit deposition material and/or may be adapted to deposit further deposition material, in order to form a layered device.

In a further aspect of the invention there is provided a transistor comprising a gate, a drain contact and a source contact, wherein at least one of the drain contact and the source contact is tapered in at least one of a plane perpendicular to, or a plane parallel to, the direction of current flow between the source contact and the drain contact when the transistor is in operation.

The transistor may comprise multiple gates (lateral and/or vertical geometry), and/or multiple drain contacts and/or multiple source contacts.

Preferably said at least one of the drain contact and the source contact tapers to a minimum thickness in said one or each plane at a point between its ends, and preferably at a point midway between its ends.

In a yet further aspect of the invention there is provided a butterfly shaped transistor, particularly a butterfly organic transistor.

The butterfly shape of drain and source electrodes permits device geometry to be constructed with a minimum in leakage current due to gate-to-drain and/or gate-to-source electrode overlap. This is also true for some alternate geometries that are possible with the method of manufacture as described herein.

For instance, a preferred layout of ink reservoir landing sites promotes line bridging between the sites that results in a continuous contact (for instance, drain and source) edge that still permits transistor action but with minimum gate-to-drain and/or gate-to-source electrode contact overlap. Thus there is provided a device with good on-off current switching ratio characteristics. The finite width of the line relates to issues such as contact resistance and current handling.

In another aspect of the invention there is provided a surface for use in forming an electronic device, arranged so that deposition material deposited on a receiving portion of the surface will flow to a desired portion of the surface.

There is also provided a surface for use in forming an electronic device, arranged so that deposition material deposited on the surface will flow to a desired portion of the surface by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow.

In a further aspect of the invention there is provided a surface for use in forming an electronic device, comprising a selected portion having a desired wetting property and arranged so that the distribution of deposition material on the surface is dependent upon the wetting property of the selected portion.

The present invention also relates to the use of surface wetting patterns.

The invention provides in one aspect the creation of a pre-shaped surface pattern that may incorporate an ink reservoir location that serves to feed ink to the whole, or to part, of the pattern by surface tension and/or interfacial energy driven transport.

The pattern may be defined using laser direct ablation, for instance of a specific surface or a surface pre-coated with a layer for instance a non-wetting, preferably self-assembled, monolayer.

For the latter case an excimer laser may define features - that can be sub-micron if desired (ultra violet wavelength of light) - on the surface by ablating particular areas, for instance areas of the non-wetting film.

This can provide abrupt regions of wetting and non-wetting surface that afford containment and/or directional flow for the ink deposited at the reservoir site or sites. The ink reservoir site or sites are preferably located outside of the active region of the device but are preferably directly connected to the or each active region by the specifics of the wetting/non-wetting pattern.

The or each ink reservoir site or land may be deliberately made large enough to cater for a wide range of cone angle error thereby easing the restriction on the OEM printhead technology (including, for instance high resolution spraying and/or liquid continuous jet streaming for instance defined by a fixed duration actuation pulse).

The specific design of the wetting region pattern may take into account the need to feed ink from more than one location to promote a more uniform liquid pool and concomitant thin film solid coating covering this region.

Thus a Tsunami-like wash-over of ink as droplets hit and spread across a surface can be removed. The ink landing on the reservoir pads can impact and spread within a safe zone before being carried away from the impact site, for instance by wetting induced forced flow.

Preferably, enhanced flow can be achieved by introducing the equivalent of a gas jet shower that can gently force ink to flow into regions limited under non-forced conditions by geometrical and/or surface tension constraints.

Three-dimensional designs, which may be complex and which may include designs requiring enclosed duct filing such as is the case for lab-on-a-chip and micro total analysis systems, can be achieved.

A self-assembled non-wetting monolayer can be deposited for example using drop-on-demand ink jet printing, and be patterned in a step-and-repeat manner using an integrated UV Lamp patterning or Laser digital pattern transfer to create wetting and non-wetting regions on the surface. Ink may then be delivered to the surface. In particular, a transparent conductor ink may then be delivered to the surface using ink jet printing that segregates to the wetting lands to produce a required transparent conductor layout, with the patterning defining monolayer material being removed using chemical means.

A fluid may be deposited within grooves formed on a substrate, preferably so as to partially fill the grooves. A glass plate which has been coated with a self-assembled monolayer (SAM) may provide a highly non-wetting surface. A laser may be scanned over the plate surface to define a series of grooves in the near surface and plate surface, which are below the detection limit of the eye and form a set of containment trenches. The grooves, which can be produced using other methods, can be in a single direction (x or y) or in orthogonal directions (x and y) where the cross-over points provide connectivity between the both axes. The resulting grooves are filled with fluid which can be achieved using precision spraying or drop-on-demand ink jet printing, where the wetting nature of the groove wall causes the ink to flow into the etched trench leaving the surface free of ink because of the differential nature of the surface energy in the groove and that related to the non-wetting SAM coating on the exposed surface between the grooves.

The composition of ink used, for instance transparent conductor ink, can be so modified so as to promote spontaneous localised dewetting due to the nature of the ink viscosity and surface tension, and the substrate surface energy, which can induce differential wetting behaviour via the Marangoni effect promoting or resisting natural wetting behaviour. In this respect, mixed solvent inks are known to affect the wetting of surfaces and, in some cases, to promote controlled patterning of surfaces from an array of discrete dots to interconnected spinoidal dewetting and dendritic patterning.

Fluid flow, in particular flow of the deposition material, can also be achieved by differential thermal energy introduced by a heating means, such as an infrared lamp or laser set-up that causes the local temperature, for instance of the device being formed or the surface on which the deposition material is deposited, to be changed. A suitable change may be of several degrees Celsius.

Such change in temperature can provide a driving force to promote fluid flow without adversely affecting the rheology of the fluid, for instance the deposition material.

Such temperature processing may be modified to alter the temperature at the liquid-solid contact line resulting in a liquid surface tension gradient that either promotes fluid outflow or causes the liquid to retract thereby giving a potential mechanism to promote device trimming of specific properties. The liquid referred to may be the deposition material, and the liquid-solid contact line referred to may be the contact line between the deposition material and the surface on which the deposition material is deposited or to which it flows.

In a further aspect, a selective dewetting mechanism, such as spinoidal dewetting may be used to produce a porous surface, for example a porous contact, as might be expected on a chemitransistor or electronically controlled barrier membrane, suitable, for instance, for micro, nano, and molecular applications.

The deposition material may comprise one or more of a wide variety of inks, including:-

- Ink suitable for UV curing
- Ink suitable for cationic curing
- Ink adapted to be subject to a phase change before, during, or following deposition
- Solid phase ink
- Aqueous-based ink

- Organic solvent-based ink
- Solutions
- Multi-phase ink
- Ormocers

Such ink may contain one or more of:-

- Organic nanoparticles (i.e., pentacene)
- Inorganic nanoparticles (i.e., silicon, germanium)
- DNA
- Carbon nanotubes, fibres, towers, and wires
- Molecular species
- Rotaxane
- Polysilanes and siloles
- Polymer(s)
- Siloxane
- Bioelectronic compounds
- Zinc oxide

The ink may comprise, one or more of various modifiers:-

- Viscosity [Newtonian; shear thinning (pseudo-plastic); shear thickening (dilitant); Bingham]
- Surface tension
- Electronic conductivity
- Light absorbance
- Solvent evaporation [humectants]
- Dispersants
- Surfactants
- Elasticity agents
- Anti-fungal agents
- Chelating agents
- pH controllers

- Corrosion inhibitors
- Defoamers

The deposition material may be dispensed or deposited, preferably to build any or all layers of a specific device, using one or more of:-

- Pin transfer
- Nano pipette
- Precision impulse spraying [includes electrostatic and nebuliser methods]
- Continuous ink jet
- Gravure
- Flexographic
- Offset
- Dip (including roll transfer through a fluidised bed)
- Solid source ablation
- Solid particle ink jet
- Semi-solid continuous strip transfer (i.e., like toothpaste with pressure valve pulsing)
- Casting
- Vapour transfer condensation
- Electrophoresis

Semi-solid and/or solid materials or particles may be steered/deposited on the landing site where they may be thermally melted (local or whole area process) and caused to reflow under the action of the ensuing liquid rheology, surface wetting driving forces, and/or the specific differential surface wetting (liquid)-surface (solid receiving surface) driving energy.

Localised liquid wetting/dewetting may be achieved using various methods. The step of arranging the surface may comprise selectively controlling or patterning the surface, or the receiving surface energy, and the step of arranging the surface may comprise, or may be carried out using, one or more of:-

- Electrowetting
- Surface electronic charge pumping
- Roughening
- Controlled heterogeneity
- Selective imbibition
- Surface curvature
- Whole area lamp technology [i.e., gas discharge lamp that emulates the properties of an excimer laser but at lower cost]
- Solid-state LED or laser in discrete or array format
- Selective area deposited SAMs

Preferably the step of arranging the surface comprises treating the surface through chemical exchange with laser energy activated species that reside adjacent to the surface.

Preferably the surface, or a substrate medium located at the surface, comprises one or more of:-

- Glass
- Plastic
- Metal
- Ceramic
- Paper
- Crystal wafers
- Plant surfaces

The surface, or the substrate media, may be either planar or three-dimensionally shaped, and where appropriate an initial levelling and electrically conditioning layer may be selectively deposited to assist layer adhesion and device performance.

In a further aspect it is possible to promote layer property grading by virtue of changes in the chemistry of the liquid deposited at the landing site or receiving portion of the surface.

In further aspects there is provided alone or in any appropriate combination:- a system which is droplet placement error tolerant; laser direct write defined wetting regions; graded wetting zones along contact pattern length to assist fluid levelling; dual zone low resolution printing lands; built in 3 dimensional vias; straight edge alignment; sub-micron pattern resolution; planar interconnections to connect multiple transistors; common or individual transistor design for multiple device circuits; 3 dimensional electrical contact micro via; planar insulator or semiconductor coating leaving an exposed contact pad; all-additive processing; selective area photoexposure which promotes differential wetting leading to liquid coat patterning and modified liquid flow behaviour, for instance for construction of auto-aligned insulating vias; butterfly shaped thin film transistor; staggered organic field effect transistor configuration; dual connections to gate, drain, and source contacts; drain and source contacts constructed as 3 dimensional micro vias; semiconductor filling a gate channel trench only; non-wetting surface between drain-source contact retained for molecular ordering; continuously graded wetting promoting fluid flow and levelling; step graded wetting forcing fluid direction; cross section of contact designed for optimum flow for levelling in device zone; hybrid laser-ink jet printing process; laser direct write deposition; laser direct write ablation of whole area non-wetting coating; liquid levelling behaviour; multiple droplets impacting on ink reservoir contact land; limited wetting by printing more ink on to dried initial coating in order to form 3 dimensional micro via for external contacting and device interconnectivity; determination of optimum shape of wetting land including number of ink reservoir lands to be included within wetting pattern; rheological modification using photoconversion processes to affect viscoelastic damping behaviour; and fluid dispensing onto reservoir land by method other than ink jet printing.

The invention also provides a method, apparatus, device, and surface substantially as herein described with reference to Figures 1 to 6 of the accompanying drawings.

Any feature in one aspect of the invention may be applied to other aspects of the invention, in any appropriate combination.

Method features may be applied to apparatus features and *vice versa*. Features which are provided independently may be provided dependently and *vice versa*.

Preferred features of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is an illustration of part of a transistor according to one embodiment, viewed from above;
Figure 2 is an illustration of fluid dispensing onto a surface to form the transistor of Figure 1, viewed from above;
Figure 3 is an illustration of the transistor of Figure 1, viewed from above and with the central gate contact shown as partially transparent to show the organic semiconductor;
Figure 4 is an illustration of a surface from above in one embodiment, and deposition material dispersed over the surface, in side view;
Figure 5 is an illustration of a transistor according to one embodiment, in side view; and
Figure 6 is an illustration of an Inverter (NOT circuit) constructed using organic field effect transistors, viewed from above.

The method of manufacture, in its preferred embodiment, is used to make a wide range of electronic devices, including transistors, resistors, conductors, diodes, capacitors, inductors, surface coils, josephson junctions, opto-electronic devices such as photovoltaic cells and photodiodes, quantum wire devices and interconnections, and composite devices made from a plurality of such devices, and to make a wide range of circuits formed from such devices.

Part of one such device, an organic field effect transistor (OFET), is shown in Figure 1, viewed from above. The transistor includes a drain contact 1 and a source contact 3 separated by a gate 5. The drain contact and the source contact each includes droplet impact lands, or receiving portions, 7, 9.

In making the device the deposition material, in this case a conductor, is deposited on the droplet impact lands 7, 9 and flows to cover desired areas thus forming the drain contact 1 and the source contact 3. In this case, the deposition material is an antimony tin oxide nanoparticulate dispersion although other materials can be used, such as any solvent based or other spreadable ink.

In the present example the deposition material is deposited using an ink jet printing technique. In other examples, instead of such ink jet printing technique, any technique which can deposit a pre-determined amount of material onto a pre-determined location is used, such as drop on demand printing techniques, and more particularly high resolution spraying or liquid continuous jet streaming.

The portions of the surface on which the drain contact 1 and the source contact 3 are located are, in the preferred embodiment, treated prior to deposition to alter the wetting properties of those portions of the surface. In the present example, that treatment is by laser direct ablation of the surface.

In alternative embodiments, the treatment is by corona discharge or by application of other electro-magnetic radiation.

The change in wetting properties of portions of the surface has the effect that, when the deposition material lands on the droplet impact lands its flow is restricted, in whole or part, to desired areas, in this case the drain contact 1 and source contact 3 areas, by the difference in wetting properties between those desired areas and adjacent areas of the surface.

The droplet impact lands, or receiving portions, in these embodiments act as reservoirs from which the deposition material flows to desired portions of the surface, contained by the variation in wetting properties across the surface. In such embodiments, the droplet impact lands, or receiving portions, are for example of a size of the order of the resolution of the device applying the deposition material, or larger. In contrast, parts of the desired portions of the surface to which the deposition material flows from the droplet impact lands, or receiving portions, are smaller than the resolution of the device applying the resolution material. Thus such embodiments enable the formation of electronic devices with features of a smaller scale than possible with conventional printing techniques.

Furthermore, in particular ones of such embodiments, the droplet impact lands, or receiving portions, are remote from parts of the desired portions of the surface, to which deposition material flows. Thus, those desired portions are not affected by spatter of the deposition material, or washover of impact waves of the deposition material, caused by impact of the deposition material on the droplet impact lands, or receiving portions.

Those features of preferred embodiments are illustrated in a simple way in Figure 1 where it can be seen that the droplet impact lands 7, 9 are of larger scale than the central portion of both the drain contact 1 and the source contact 3. The droplet impact lands 7, 9 are also relatively remote from those central portions, so that the central portions, at least, are not affected by spatter of the deposition material, or washover of impact waves of the deposition material.

Figure 2 shows one part of surface on which the drain contact 1 of the embodiment of Figure 1 is formed. A droplet of deposition material 10 is also shown immediately after it has landed on one of the fluid reservoir lands, or droplet impact lands or receiving portions, 7 and before the deposition material has started to flow over the surface.

As indicated on the figure, the wetting properties of the area on which the drain contact 1 is formed vary from an area of lower wetting to an area of higher wetting. This variation of wetting properties produces a variation in depth of the deposition material after it has flowed over the surface, and enables further control over the properties of the electronic device formed, in this case a transistor.

Figure 3 shows more features of the transistor of Figure 1, including drain contact connections 20, 22, source contact connections 24, 26, gate contact connections 28, 30, organic semiconductor 32 forming a gate, and gate insulator 34. The gate contact connection 28 has been shown as being partially transparent in the figure to show the location of the organic semiconductor 32 forming the gate.

In the embodiment of Figures 1 and 3, the deposition material is a conductor, and is deposited to form the drain contact 1 and the source contact 3. However, in alternative embodiments, the deposition material is an insulator, a semiconductor, or a superconductor, and is deposited to form other devices or other parts of devices.

The feature of variation in wetting properties over the desired portion of a surface is illustrated further with reference to Figure 4.

A deposition portion 60 of a surface is shown from above in Figure 4a. The variation in wetting properties of the surface over the deposition portion 60 is shown by the variation in shading. In this example, the deposition portion 60 comprises a desired portion 61 and a receiving portion 64.

Deposition material 62 is deposited on the receiving portion 64 of the surface and then flows to the desired portion 61. The deposition material only covers the deposition portion 60 and not adjacent portions of the surface due to differences in wetting properties between the deposition portion 60 and such adjacent portions.

Figure 4b shows the deposition portion 60 of the surface in side view following flow of the deposition material 62 over the deposition portion 60. As can be seen, the

depth of the deposition material 62 varies over the deposition portion 60, including the desired portion 61, in dependence upon the wetting properties of the surface.

Further layers are added to form an electronic device as required, as shown in Figure 5 in which a planar semiconductor coating 70 and metal contact layer 72 have been added to the deposition portion of Figure 4. It can be seen that the deposition material 62, at its thickest point, connects to the metal contact layer 72 to form an electrical circuit interconnection.

In further embodiments, more complex surface patterns comprising areas with different wetting properties are provided, together with a plurality of droplet impact lands, or receiving portions, and deposition material deposited on those lands or receiving portions flows to cover the surface pattern. By controlling the wetting properties of the surface and controlling the deposition of the deposition material, coverage of the surface pattern to a desired depth is obtained in such embodiments. In particular embodiments, a uniform depth of deposition material is obtained on desired portions of the surface.

Figure 6 shows an example of a circuit produced using a surface pattern which results in two organic field effect transistors being deposited side by side. Connections are made between the transistors to form a NOT circuit. Each of the organic field effect transistors is formed in the same way as the organic field effect transistor of Figures 1 and 3.

In alternative embodiments, the containment of the deposition material within a desired surface pattern is assisted by the laying down of other physical surface features such as trenches and wells. The distribution of the deposition material in some embodiments is aided by applying flowing fluid to the deposition material to assist the flow of the deposition material over the surface.

In one embodiment, a channel or gap of known width is created by printing etch resist and UV curing it. Then a solvent based ink, such as antimony tin oxide

nanoparticulate dispersion, for transparent conductors, is printed so that it fills the channel created by the etch resist. The conductor material is dried after printing and then the etch resist is removed by soaking in acetone or such like solvent.

In other embodiments, various features described above may be replaced by alternative features.

In particular, the deposition material can comprise any one of a wide variety of inks, including:-

- Ink suitable for UV curing
- Ink suitable for cationic curing
- Ink adapted to be subject to a phase change before, during, or following deposition
- Solid phase ink
- Aqueous-based ink
- Organic solvent-based ink
- Solutions
- Multi-phase ink
- Ormocers

Such ink in particular embodiments contains one or more of:-

- Organic nanoparticles (i.e., pentacene)
- Inorganic nanoparticles (i.e., silicon, germanium)
- DNA
- Carbon nanotubes, fibres, towers, and wires
- Molecular species
- Rotaxane
- Polysilanes and siloles
- Polymer(s)
- Siloxane
- Bioelectronic compounds

- Zinc oxide

The ink comprises in certain embodiments, one or more of various modifiers:-

- Viscosity [Newtonian; shear thinning (pseudo-plastic); shear thickening (dilitant); Bingham]
- Surface tension
- Electronic conductivity
- Light absorbance
- Solvent evaporation [humectants]
- Dispersants
- Surfactants
- Elasticity agents
- Anti-fungal agents
- Chelating agents
- pH controllers
- Corrosion inhibitors
- Defoamers

In an embodiment described above, an ink jet printing technique is used. In alternative embodiments, other methods of dispensing/depositing the deposition material used to build any or all layers of a specific device include:-

- Corrosion inhibitors
- Defoamers
- Pin transfer
- Nano pipette
- Precision impulse spraying [includes electrostatic and nebuliser methods]
- Continuous ink jet
- Gravure
- Flexographic
- Offset
- Dip (including roll transfer through a fluidised bed)

- Solid source ablation
- Solid particle ink jet
- Semi-solid continuous strip transfer (i.e., like toothpaste with pressure valve pulsing)
- Casting
- Vapour transfer condensation
- Electrophoresis

In further embodiments semi-solid and/or solid materials or particles are steered/deposited on the landing site where they are thermally melted (local or whole area process) and caused to reflow under the action of the ensuing liquid rheology, surface wetting driving forces, and the specific differential surface wetting (liquid)-surface (solid receiving surface) driving energy.

In an embodiment described above, a surface is treated by laser direct ablation. There are alternative methods to achieve localised liquid wetting/dewetting. In alternative embodiments, one or more alternative methods can be used to selectively control or pattern the receiving surface energy, including:-

- Electrowetting
- Surface electronic charge pumping
- Roughening
- Controlled heterogeneity
- Selective imbibition
- Surface curvature
- Whole area lamp technology [i.e., gas discharge lamp that emulates the properties of an excimer laser but at lower cost]
- Solid-state LED or laser in discrete or array format
- Selective area deposited SAMs

In some embodiments, the receiving surface laser irradiation includes using the laser not to treat the surface directly but through chemical exchange with laser energy activated species that reside adjacent to the surface to be treated.

In various embodiments, the substrate medium used in device manufacture comprises one or more of:-

- Glass
- Plastic
- Metal
- Ceramic
- Paper
- Crystal wafers
- Plant surfaces

Such substrate media are either planar or three-dimensionally shaped, and where appropriate an initial levelling and electrically conditioning layer is selectively deposited to assist layer adhesion and device performance.

The Applicant asserts design right and/or copyright in the accompanying drawings.

It will be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention.

Each feature disclosed in the description, and (where appropriate) the claims and drawings may be provided independently or in any appropriate combination.

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

CLAIMS

1. A method of forming an electronic device comprising arranging a surface such that deposition material deposited on a receiving portion of the surface will flow to a desired portion of the surface.

2. A method according to Claim 1, comprising using the technique of drop on demand printing to deposit at least one droplet of deposition material.

3. A method according to Claim 1 or 2, further comprising depositing the deposition material on the receiving portion in such a way that a pre-determined coverage of the desired portion by the deposition material is obtained.

4. A method according to any preceding claim, wherein the step of arranging the surface comprises forming a surface pattern.

5. A method according to any preceding claim, wherein the receiving portion comprises a reservoir for the deposition material, and preferably the reservoir comprises a portion of the surface having a desired wetting property arranged so as to control flow of deposition material from the reservoir.

6. A method according to any preceding claim, wherein the receiving portion is separate from the desired portion, and preferably is remote from the desired portion.

7. A method according to any preceding claim, wherein the desired portion comprises an active region of the electronic device to be formed, and preferably the active region is a region where current flows and/or where voltage is applied when the device is in use.

8. A method according to any preceding claim, comprising arranging the surface so that deposition material deposited on one or each of a plurality of receiving

portions of the surface will flow to a desired portion of the surface, and preferably will flow to a plurality of desired portions of the surface.

9. A method according to any preceding claim, comprising arranging the surface so that the receiving portion is at least as large as the resolution with which the deposition material can be deposited on the surface by apparatus used to put the method into effect.

10. A method according to any preceding claim, wherein the step of arranging the surface comprises arranging the surface so that the deposition material deposited on the surface will flow by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect.

11. A method of forming an electronic device, comprising arranging a surface and/or selecting deposition material such that the deposition material when deposited on the surface will flow to a desired portion of the surface by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect.

12. A method according to Claim 11, comprising using the technique of drop on demand printing to deposit at least one droplet of deposition material.

13. A method according to any preceding claim, wherein the step of arranging the surface comprises providing a selected portion of the surface with a desired wetting property, preferably by changing the wetting property of the selected portion of the surface.

14. A method of forming an electronic device, comprising providing a selected portion of a surface with a desired wetting property and depositing deposition material on the surface, so that the distribution of the deposition material on the surface is dependent upon the wetting property of the selected portion.

15. A method according to Claim 14, comprising depositing the deposition material using the technique of drop on demand printing.

16. A method according to any of Claims 13 to 15, comprising providing variation of the wetting property over at least part of the selected portion, wherein preferably the variation is a continuous variation.

17. A method according to any of Claims 13 to 16, comprising providing a discontinuous variation of the wetting property between at least part of the selected portion and at least one adjacent portion of the surface.

18. A method according to any of Claims 13 to 17, wherein a difference in the or a wetting property between the selected portion of the surface and a further portion of the surface causes containment of the deposition material, and preferably causes containment of the deposition material within at least part of the selected portion or within at least part of the further portion.

19. A method according to any preceding claim, further comprising coating the surface.

20. A method according to Claim 19, wherein the step of coating the surface comprises coating the surface with a layer having a different wetting property from the surface, and preferably the layer comprises a non-wetting layer and/or comprises a monolayer and/or comprises a self-assembled layer.

21. A method according to any preceding claim, further comprising applying radiation to the surface and/or to the or a layer on the surface, preferably so as to change the or a wetting property.

22. A method according to Claim 21, wherein the radiation comprises electromagnetic radiation, preferably ultraviolet radiation.

23. A method according to Claim 22, wherein the radiation comprises laser radiation.

24. A method according to Claim 23, comprising applying the laser radiation using an excimer laser.

25. A method according to any preceding claim, comprising treating the surface and/or the or a layer on the surface by laser ablation and/or by corona discharge, preferably so as to change the or a wetting property.

26. A method according to any preceding claim, wherein the step of arranging the surface comprises providing a temperature variation across at least part of the surface, and preferably that temperature variation causes flow of the deposition material across at least part of the surface.

27. A method according to any preceding claim, further comprising heating or cooling the deposition material and/or at least part of the device, preferably so as to control flow of the deposition material.

28. A method according to any preceding claim, wherein at least one dimension of the desired portion and/or the surface pattern and/or the selected portion is less than one micron and/or is of the order of the wavelength of ultra-violet light.

29. A method according to any preceding claim, further comprising applying flowing fluid to the deposition material to assist the flow of the deposition material over the surface, and preferably the flowing fluid comprises a gas jet shower.

30. A method according to Claim 29, whereby flow of the deposition material into a region of the surface which would otherwise be restricted by geometrical effects and/or surface tension effects is obtained.

31. A method according to any preceding claim, comprising depositing deposition material on the receiving portion using at least one of ink jet printing,. an OEM printhead, high resolution spraying, and liquid continuous jet streaming, preferably liquid continuous jet streaming defined by a fixed duration actuating pulse.

32. A method according to any preceding claim wherein the electronic device comprises at least one of a transistor, a resistor, a conductor, a diode, a capacitor, an inductor, a surface coil, a josephson junction, an organic, inorganic or hybrid organic-inorganic structure, an opto-electronic device such as a photovoltaic cell or photodiode, a quantum wire device and/or interconnection, or a composite device made from a plurality of such devices, and preferably comprises a butterfly transistor.

33. A method according to any preceding claim, comprising repeatedly depositing deposition material and/or depositing further deposition material, in order to form a layered device.

34. Apparatus for forming an electronic device comprising means for arranging a surface such that deposition material deposited on a receiving portion of the surface will flow to a desired portion of the surface, and means for depositing deposition material on a receiving portion of a surface.

35. Apparatus according to Claim 34, wherein the depositing means is adapted to use the technique of drop on demand printing to deposit at least one droplet of deposition material.

36. Apparatus according to Claim 34 or 35, wherein the arranging means is adapted to select and/or to change a property of the receiving portion.

37. Apparatus according to any of Claims 34 to 36, wherein the depositing means is adapted to deposit the deposition material on the receiving portion in such a way

that a pre-determined coverage of the desired portion by the deposition material is obtained.

38. Apparatus according to any of Claims 34 to 37, wherein the arranging means is adapted to form a surface pattern on the surface.

39. Apparatus according to any of Claims 34 to 38, wherein the receiving portion comprises a reservoir for the deposition material, and preferably the reservoir comprises a portion of the surface having a desired wetting property arranged so as to control flow of deposition material from the reservoir.

40. Apparatus according to any of Claims 34 to 39, wherein the receiving portion is separate from the desired portion, and preferably is remote from the desired portion.

41. Apparatus according to any of Claims 34 to 40, wherein the desired portion comprises an active region of the electronic device to be formed, and preferably the active region is a region where current flows and/or where voltage is applied when the device is in use.

42. Apparatus according to any of Claims 34 to 41, wherein the arranging means is adapted to arrange the surface so that deposition material deposited on one or each of a plurality of receiving portions of the surface will flow to a desired portion of the surface, and preferably will flow to a plurality of desired portions of the surface.

43. Apparatus according to any of Claims 34 to 42, wherein the arranging means is adapted to arrange the surface so that the receiving portion is at least as large as the resolution with which the deposition material can be deposited on the surface by apparatus used to put the method into effect.

44. Apparatus according to any of Claims 34 to 43, wherein the arranging means is adapted to arrange the surface so that the deposition material deposited on the

surface will flow by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect.

45. Apparatus for forming an electronic device, comprising means for arranging a surface such that deposition material deposited on the surface will flow to a desired portion of the surface by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow and/or the Marangoni effect, and means for depositing the deposition material on the surface.

46. Apparatus according to Claim 45, wherein the depositing means is adapted to deposit at least one droplet of deposition material using the technique of drop on demand printing.

47. Apparatus according to any of Claims 34 to 46, wherein the arranging means is adapted to change a wetting property of a selected portion of the surface.

48. Apparatus for forming an electronic device, comprising arranging means adapted to change a wetting property of a selected portion of the surface so that the distribution of deposition material deposited on the surface is dependent upon the wetting property of the selected portion, and means for depositing deposition material on the surface.

49. Apparatus according to Claim 48, wherein the depositing means is adapted to deposit at least one droplet of deposition material using the technique of drop on demand printing.

50. Apparatus according to any of Claims 47 to 49, wherein the arranging means is adapted to provide variation of the wetting property over at least part of the selected portion, wherein preferably the variation is a continuous variation.

51. Apparatus according to any of Claims 47 to 50, wherein the arranging means is adapted to provide discontinuous variation of the wetting property between at least part of the selected portion and at least one adjacent portion of the surface.

52. Apparatus according to any of Claims 47 to 51, wherein the arranging means is adapted to provide a difference in the or a wetting property between the selected portion of the surface and a further portion of the surface so as to cause containment of the deposition material, and preferably so as to cause containment of the deposition material within at least part of the selected portion or within at least part of the further portion.

53. Apparatus according to any of Claims 34 to 52, further comprising means for coating the surface.

54. Apparatus according to Claim 53, wherein the coating means is adapted to coat the surface with a layer having a different wetting property from the surface, and preferably is adapted to coat the surface with a non-wetting layer and/or a monolayer and/or a self-assembled layer.

55. Apparatus according to any of Claims 34 to 54, further comprising means for applying radiation to the surface and/or to the or a layer on the surface, preferably so as to change the or a wetting property.

56. Apparatus according to Claim 55, wherein the radiation comprises electromagnetic radiation, preferably ultraviolet radiation.

57. Apparatus according to Claim 56, wherein the radiation comprises laser radiation.

58. Apparatus according to Claim 57, comprising an excimer laser.

59. Apparatus according to any of Claims 34 to 58, comprising means for treating the surface and/or the or a layer on the surface by laser ablation and/or by corona discharge, preferably so as to change the or a wetting property.

60. Apparatus according to any of Claims 34 to 59, further comprising means for providing a temperature variation across at least part of the surface, and preferably that temperature variation is such as to cause flow of the deposition material across at least part of the surface.

61. Apparatus according to any of Claims 34 to 60, further comprising means for heating and/or cooling the deposition material and/or at least part of the device, preferably so as to control flow of the deposition material.

62. Apparatus according to any of Claims 34 to 61, wherein at least one dimension of the desired portion and/or the surface pattern and/or the selected portion is less than one micron and/or is of the order of the wavelength of ultra-violet light.

63. Apparatus according to any of Claims 34 to 62, further comprising means for applying flowing fluid to the deposition material to assist the flow of the deposition material over the surface, and preferably the flowing fluid comprises a gas jet shower.

64. Apparatus according to Claim 63, whereby the applications means is arranged so as to obtain flow of the deposition material into a region of the surface which would otherwise be restricted by geometrical effects and/or surface tension effects.

65. Apparatus according to any of Claims 34 to 64, wherein the deposition means is adapted to deposit deposition material on the receiving portion using at least one of ink jet printing, an OEM printhead, high resolution spraying, and liquid continuous jet streaming, preferably liquid continuous jet streaming defined by a fixed duration actuating pulse.

66. Apparatus according to any of Claims 34 to 65, wherein the electronic device comprises at least one of a transistor, a resistor, a conductor, a diode, a capacitor, an inductor, a surface coil, a josephson junction, an organic, inorganic or hybrid organic-inorganic structure, an opto-electronic device such as a photovoltaic cell or photodiode, a quantum wire device and/or interconnection, or a composite device made from a plurality of such devices, and preferably comprises a butterfly transistor.

67. Apparatus according to any of Claims 34 to 66, wherein the deposition means is adapted to repeatedly deposit deposition material and/or is adapted to deposit further deposition material, in order to form a layered device.

68. A transistor comprising a gate, a drain contact and a source contact, wherein at least one of the drain contact and the source contact is tapered in at least one of a plane perpendicular to, or a plane parallel to, the direction of current flow between the source contact and the drain contact when the transistor is in operation.

69. A transistor according to Claim 68, wherein said at least one of the drain contact and the source contact tapers to a minimum thickness in said one or each plane at a point between its ends, and preferably at a point midway between its ends.

70. A transistor according to Claim 68 or 69, comprising a plurality of gate contacts and/or a plurality of drain contacts and/or a plurality of source contacts.

71. A butterfly shaped transistor.

72. A transistor according to any of Claims 68 to 71, constructed using a method according to any of Claims 1 to 33.

73. A surface for use in forming an electronic device, arranged so that deposition material deposited on a receiving portion of the surface will flow to a desired portion of the surface.

74. A surface for use in forming an electronic device, arranged so that deposition material deposited on the surface will flow to a desired portion of the surface by way of surface tension and/or interfacial energy driven transport and/or wetting induced forced flow.

75. A surface for use in forming an electronic device, comprising a selected portion having a desired wetting property and arranged so that the distribution of deposition material on the surface is dependent upon the wetting property of the selected portion.

76. A method substantially as herein described with reference to the accompanying drawings.

77. An apparatus substantially as herein described with reference to the accompanying drawings.

78. A device substantially as herein described with reference to the accompanying drawings.

79. A surface substantially as herein described with reference to the accompanying drawings.

ABSTRACT

ELECTRONIC DEVICE AND METHOD OF MANUFACTURE THEREOF

A method of forming an electronic device comprises arranging a surface such that deposition material (10) deposited on a receiving portion (7) of the surface will flow to a desired portion of the surface, thus providing improved control over the distribution of the deposition material and enabling formation of improved devices.

(Figure 2)

Organic Transistor and Method of Manufacture

- Droplet Placement Error Tolerant
- Laser Direct Write Defined Wetting Regions
- Graded Wetting Zones Along Contact Pattern Length to Assist Fluid Levelling
- Dual Zone Low Resolution Printing Lands
- Built-In 3-dimensional Interconnection Via's
- Straight Edge Alignment
- Sub-Micron Pattern Resolution

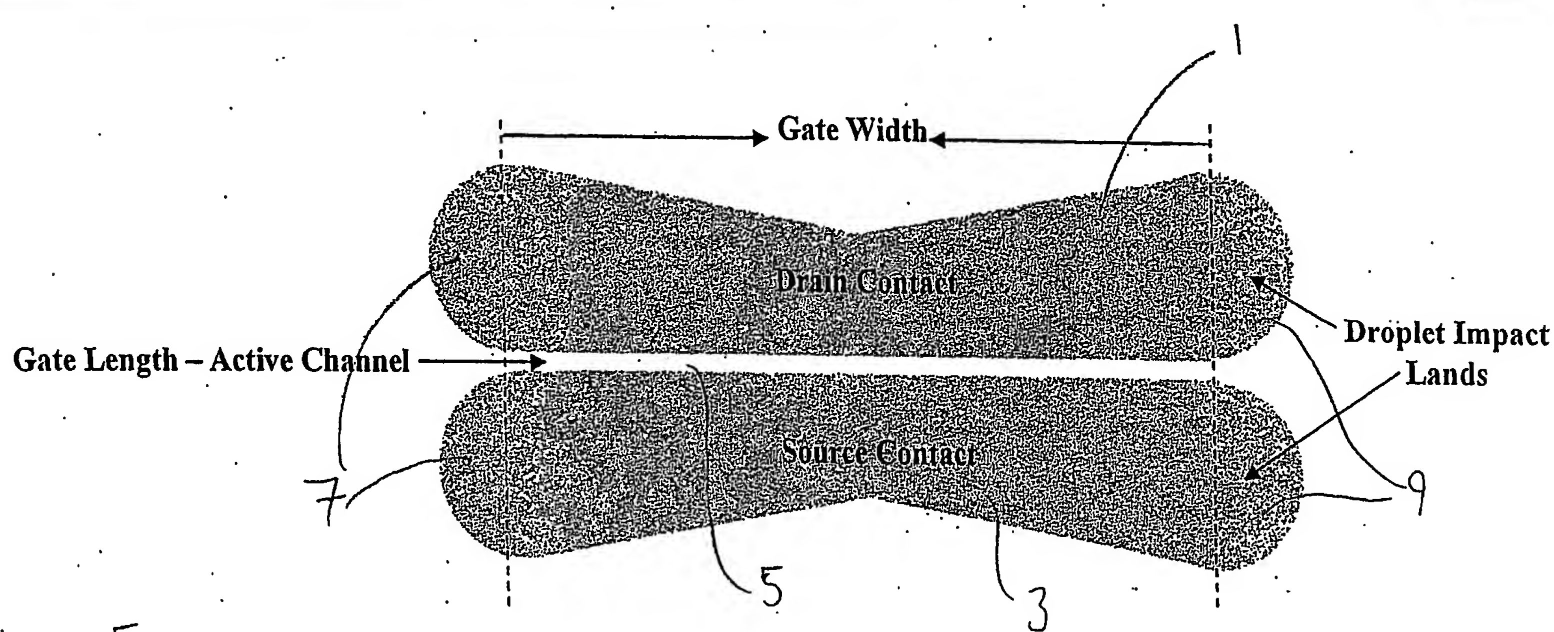


Fig 1

Drop-on-Demand Ink Jet Printer Tolerant Device Fabrication Process

Organic Transistor and Method of Manufacture

- Continuously Graded Wetting Promotes Fluid Flow and Levelling
- Step-Graded Wetting Forcing Fluid Direction
- Cross-section of Contact Designed for Optimum Flow for Levelling in Device Zone
- Hybrid Laser-Ink Jet Printing Process
- Laser Direct Write Deposition
- Laser Direct Write Ablation of Whole Area Non-Wetting Coating

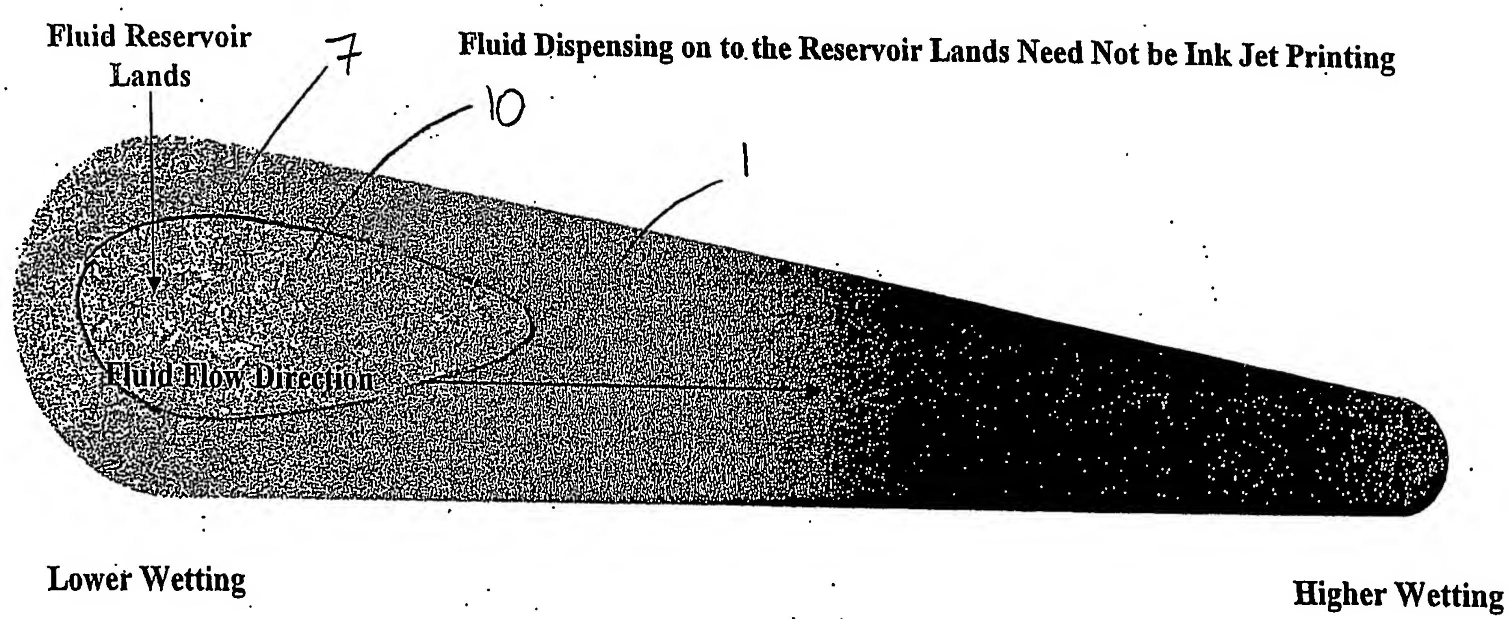


Fig. 2

Organic Transistor and Method of Manufacture

- "Butterfly" Shaped Thin film Transistor
- Staggered Organic-Field Effect Transistor Configuration
- Dual Connections to Gate, Drain, and Source Contacts
- Drain and Source Contacts Constructed as 3-Dimensional Micro Vias
- Semiconductor Shown Filling the Gate Channel Trench Only
- Non-Wetting Surface Between the Drain-Source Contacts is Retained for Molecular Ordering

Near Idealised Embedded Transistor with Exposed Contact Pads

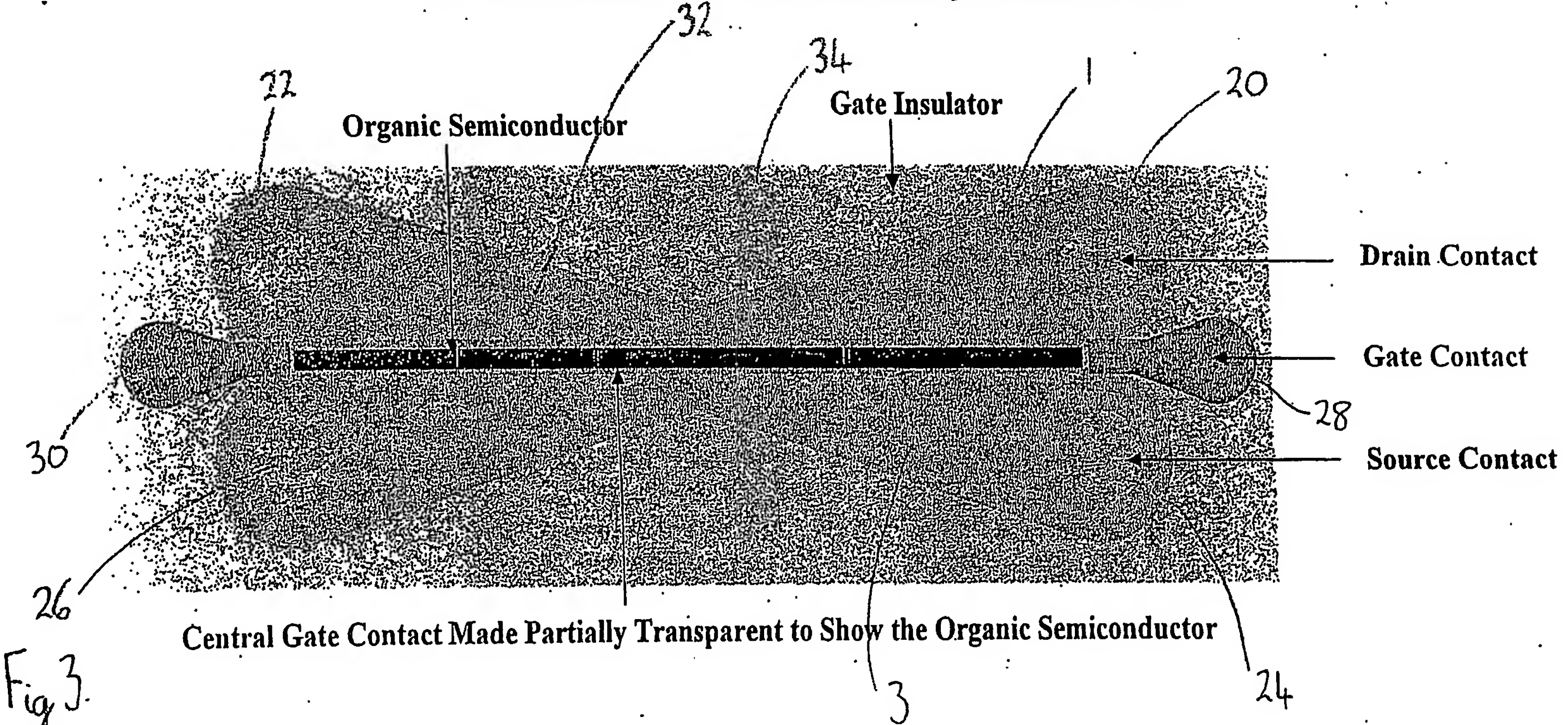


Fig 3.

Organic Transistor and Method of Manufacture

- Liquid Levelling Behaviour
- Multiple Droplets Impacting on the Ink Reservoir Contact Land
- Limited Wetting by Printing More Ink on to the Dried Initial Coating in order to Form a 3-Dimensional Micro Via for External Contacting and Device Interconnectivity
- Need to Determine Optimum Shape of the Wetting Land including Number of Ink Reservoir Lands to be included within the Wetting Pattern
- Rheological modification using photoconversion methods to affect viscoelastic damping behaviour

Fluid Dispensing on to the Reservoir Lands Need Not be Ink Jet Printing

Fig. 4

Fig. 4a

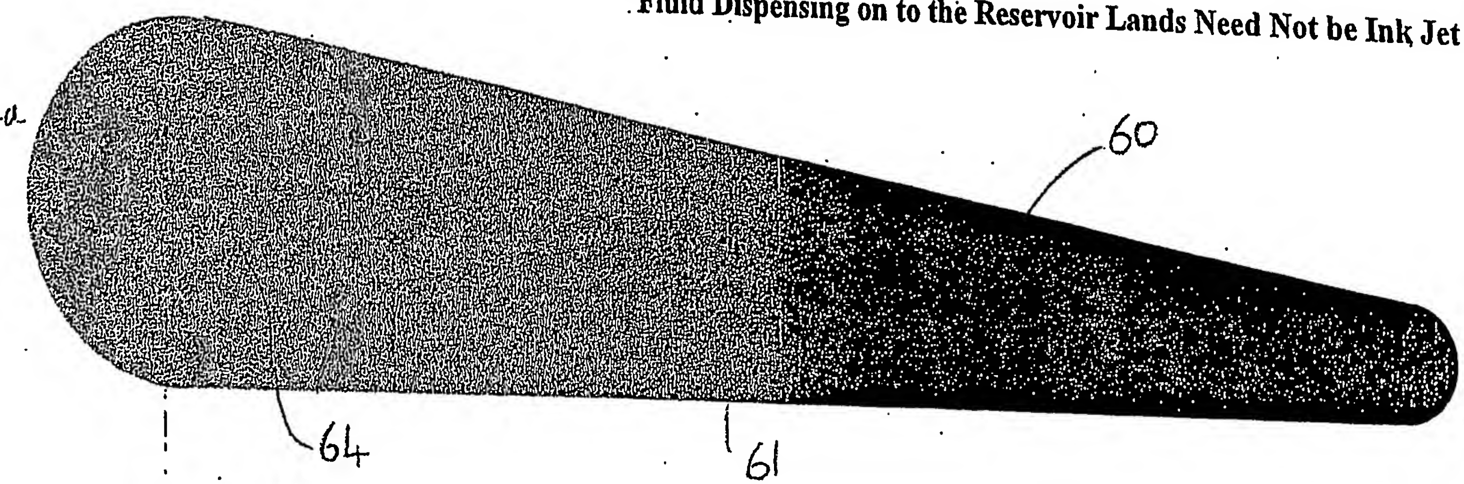
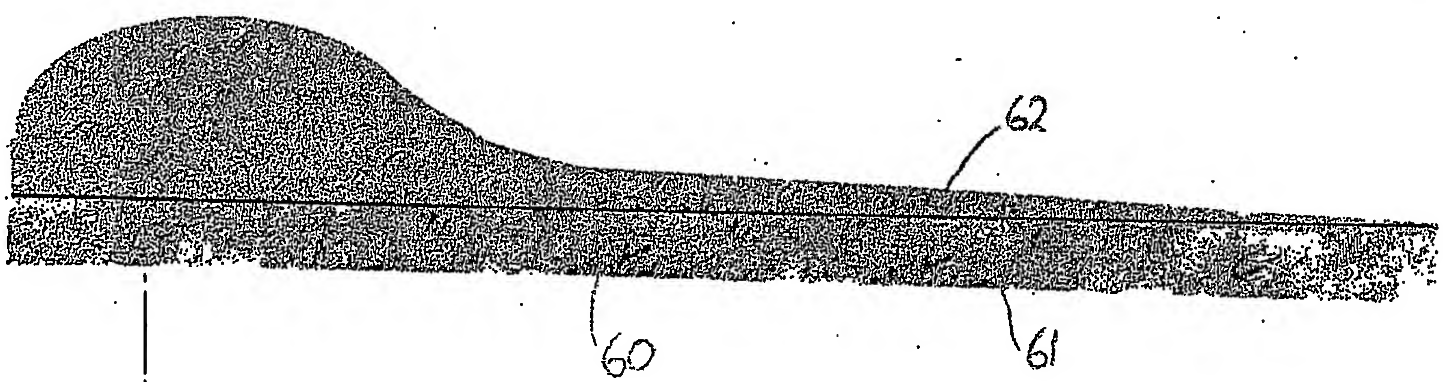


Fig. 4b.



Organic Transistor and Method of Manufacture

- 3-Dimensional Electrical Contact Micro Via
- Planar Insulator or Semiconductor Coating leaving an Exposed Contact Pad
- All-Additive Processing
- Selective area photoexposure promotes differential wetting leading to liquid coat patterning and modified liquid flow behaviour as envisaged for the construction of the auto-aligned insulating vias

Fluid Dispensing on to the Reservoir Lands Need Not be Ink Jet Printing

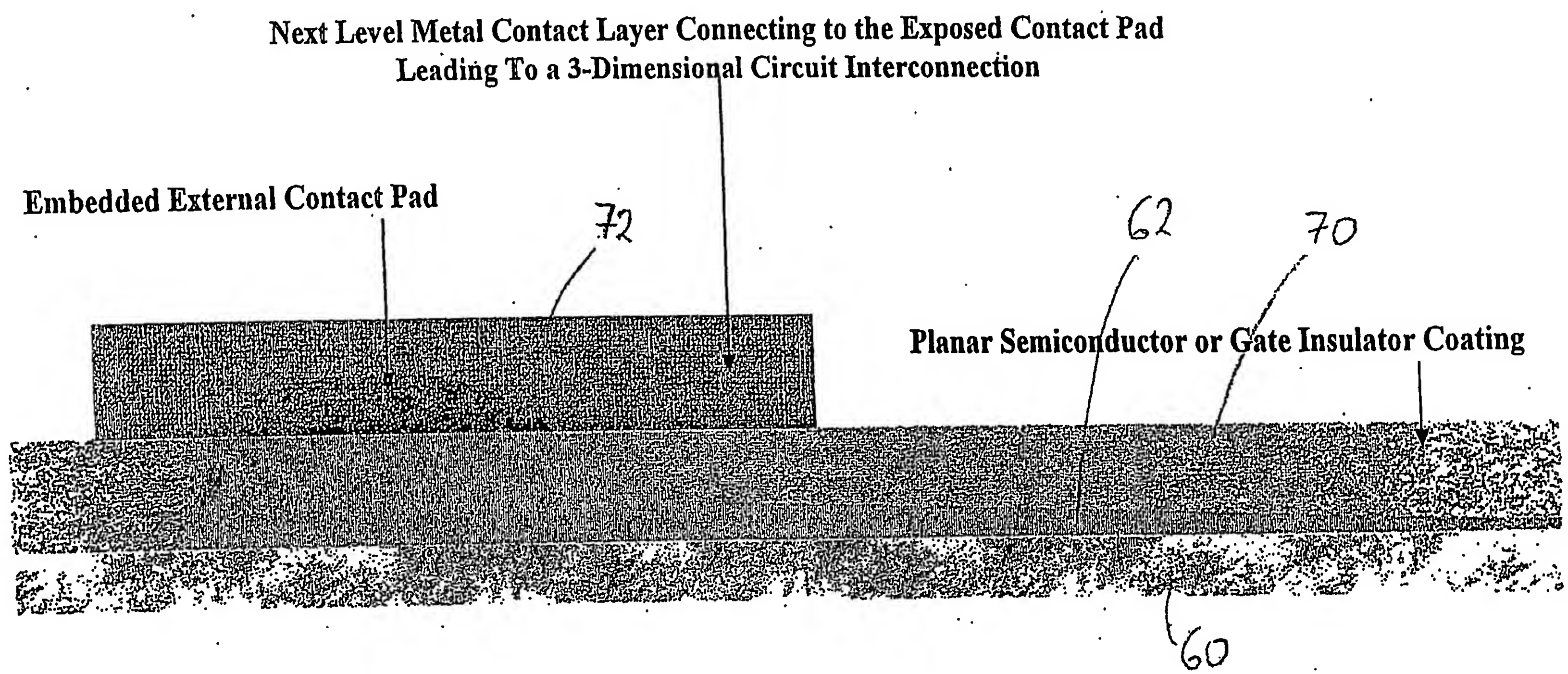


Fig. 5

Organic Transistor and Method of Manufacture

- Planar Interconnections to Connect Multiple Transistors
- Common or Individual Transistor Design for Multiple Device Circuits

Organic-Field Effect Transistor Inverter (NOT Circuit)

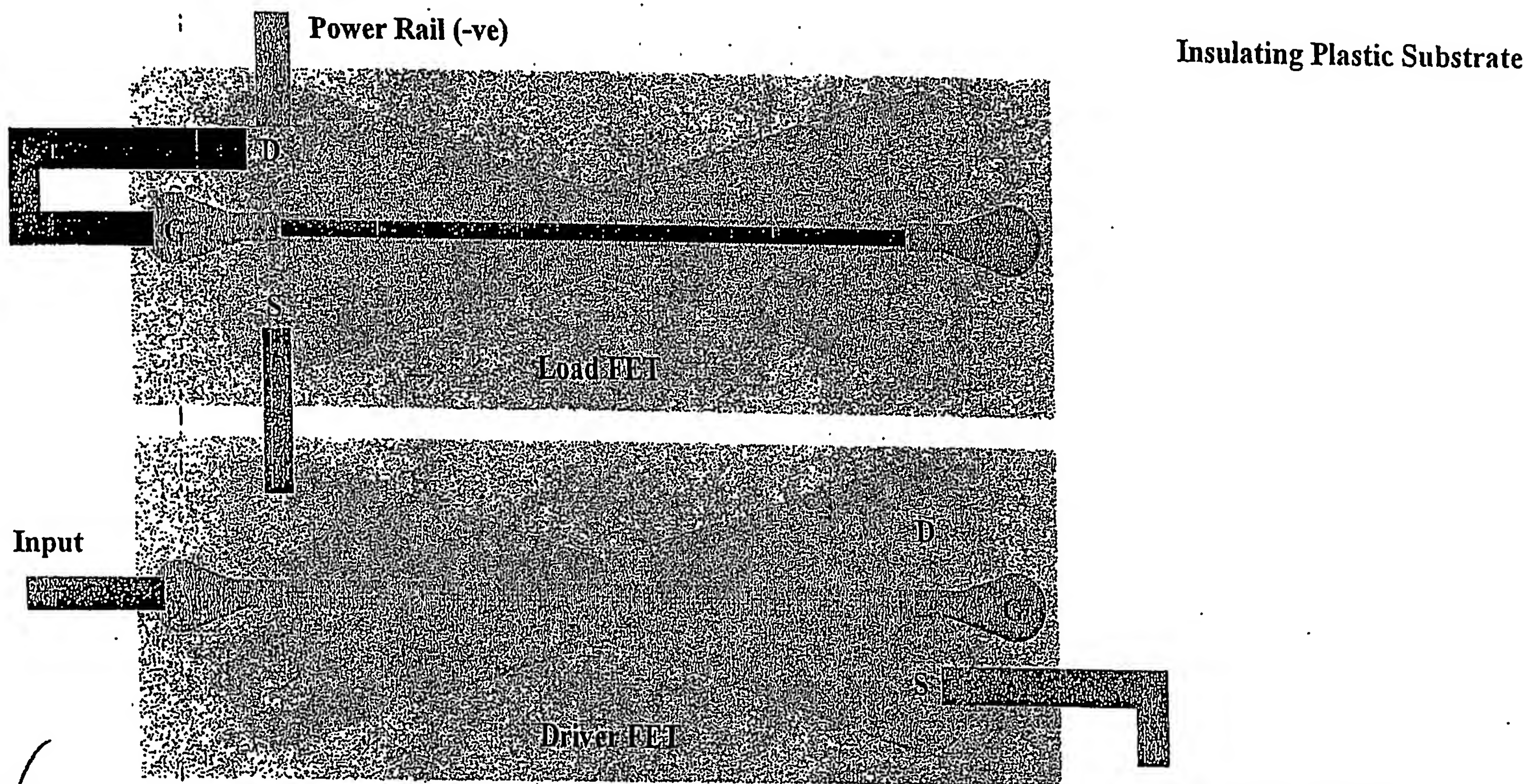


Fig 6